

Towards Mainstream Adoption of Blockchain for Socio-economic Transformation: A Proposed Framework

Short Paper

Gilbert Kpelimetime Mombazaa

University of Ghana Business School
gmkelim-etime@st.ug.edu.gh

Richard Boateng

University of Ghana Business School
richboateng@ug.edu.gh

Emmanuel Awuni Kolog

University of Ghana Business School
eakolog@ug.edu.gh

Abstract

Blockchain technology (BT) has numerous appealing characteristics for which various stakeholders have taken keen interest in it. It has gained significant attention from sectors such as supply chain, healthcare, finance, etc. Despite the huge potential BT promises, it has still not received mainstream adoption outside cryptocurrencies, for well over a decade since its invention. In this study, we have performed a systematic literature review to identify 13 key barriers to blockchain adoption and 3 broad possible solutions. Interoperability and integration with legacy systems, scalability and performance concerns, technical complexity, regulatory uncertainty, ecosystem readiness, and business model alignment, are some of the key challenges confronting general adoption of blockchain. An integrated framework is developed which is expected to encourage the mainstream adoption of BT. A key takeaway from this study is a clear roadmap of how organisations may proceed with their migration steps towards adoption of blockchain based solutions.

Keywords: DLT, acceptance, model, readiness, widespread, barriers

Introduction

Blockchain technology (BT) has been touted to hold a myriad of laudable promises for many fronts of society today. It pledges to enhance transparency, privacy and security; lower transaction cost across all manner of businesses and organisations, solve persistent problems of the present economy, like poverty and hyperinflation (Vigna and Casey 2016). Some areas of blockchain use cases with good prospects include finance, healthcare, education, government, security and privacy, energy, supply chain and Internet of Things (Upadhyay 2020). Sadly, almost after a decade and a half since its invention, blockchain has not received mainstream adoption outside of cryptocurrencies, the original application of the technology. Meanwhile, in many jurisdictions of the world, especially in developing nations, critical sectors of the economy are bedeviled with challenges, some of which can be mitigated through the application of blockchain.

The health sector for example, faces the incidence of counterfeit drugs and medications. From 2013 to 2017, the World Health Organisation (WHO) found that 42% of reported substandard and falsified medicines came from the African Region and approximately 100 000 patients die annually as a result of these fake drugs (WHO 2018). The fake drugs menace thrives because it is difficult to trace and track perpetrators along the complex supply chains. In response, blockchain has been proposed as feasible solution for the logistics and supply chain sector (Erol et al. 2021). The secure and immutable peer-to-peer decentralised network of blockchain can track and trace original drugs along the entire supply chain network, thereby allowing counterfeit drugs to be detected (Kumar et al. 2019). Similarly, blockchain can better manage

health records (Sharma and Joshi 2021) compared to current storage and retrieval systems of some health facilities (Asare et al. 2018). Yet, the adoption of blockchain in supply chain and the health sector is far from mainstream, owing to prevailing constraints.

In the education domain, the University of Nicosia adopted blockchain technology in managing students' certificates awarded in MOOC programmes (Sharples and Domingue 2016). Massachusetts Institute of Technology (MIT) and the Learning Machine company collaborated to create a digital badge for online learning based on blockchain technology (Skiba 2017). Sony Global Education similarly used the blockchain technology to build a global assessment platform to offer services for storing and managing degree information (Hoy 2017). In the same manner, blockchain is believed to offer the government sector with great potential benefits such as data integrity, transparency, mitigation of fraud and corruption, improved trust, security, and privacy (Ølne et al. 2017). Despite these promising outcomes however, the uptake of BT is still scanty in these sectors due to many barriers.

While there is preponderance of scholarly work on barriers to blockchain adoption, studies that focus on models or frameworks for addressing these constraints appear to be in the minority. In particular, frameworks that integrate blockchain adoption bottlenecks with possible solutions, are in dearth. In this study therefore, we have performed a systematic literature review to identify 13 key barriers to blockchain adoption and 3 broad possible solutions. An integrated framework is developed which is expected to encourage the mainstream adoption of BT. The theoretical lens employed in this study is principally TOE. The study addresses the following research question (RQ) and the associated sub-question:

RQ. What are the key challenges that confront the mainstream adoption of blockchain technology across applicable industry sectors and organisations?

Sub-RQ. How can a novel framework be developed to address the challenges and promote mainstream adoption of blockchain technology?

A key takeaway from this study is a clear roadmap of how organisations may proceed with their migration steps towards adoption of blockchain based solutions.

Blockchain Overview and Related Work

A blockchain may be described as a distributed database, which is shared and maintained by a peer-to-peer network (Seebacher and Schüritz 2017). It comprises of a linked sequence of blocks, containing timestamped transactions that are secured by cryptographic functions and verified by the network community. Once a record of transactions is appended to the blockchain, it cannot be modified, making blockchain an immutable record of data. Blockchains may be categorised as private, public, or consortium depending on how permission is granted to participants to join the network. Blockchain is a type of distributed ledger technology (DLT) (Babich and Hilary 2018), which has gained huge attention (Mohammed et al. 2020), since its invention in 2008 to power the bitcoin (Nakamoto 2008).

Several experts and academic researchers have attested that the application of blockchain goes beyond bitcoin as well as the financial industry to engender change across many businesses (Ølne et al. 2017). Increasingly, a number of sectors outside of FinTech have been exploring the feasibility of tapping into the great potential of BT. The energy sector is one such area where the potential of blockchain is being explored by an increasing number of startups, pilots, trials and research projects. A study of the German Energy Agency (Burger et al. 2016) on the views of energy decision makers shows that nearly 20% trust that BT is a game-changer for energy suppliers. Similarly, the health sector is a key area where BT is believed to be capable of solving the complexity of issues within the sector. According to Chukwu and Garg (2020), blockchain has the potential to surmount the problems and inefficiencies characteristic of the healthcare sector, such as counterfeiting, imprecise healthcare data, lack of stakeholder alliance, and privacy and security apprehensions. Many other industry sectors such as supply chain, education, governance, privacy and security, and Internet of Things (IoT), have garnered interest in the application of blockchain-based solutions (Upadhyay 2020).

Notwithstanding the huge potential of blockchain to transform organisations and several sectors of the economy, mainstream adoption of the technology is yet to be realised. Extant literature pinpoint several barriers against adoption of BT. Many studies (Alexopoulos et al. 2019; Batubara et al. 2018; Chhina et al. 2019; Flovik et al. 2021; Ghode et al. 2021; Hughes et al. 2019; Kouhizadeh et al. 2021; Raddatz et al. 2021;

Sadhya and Sadhya 2018; Toufaily et al. 2021) have established technology immaturity, security and data privacy, technology cost, scalability and performance issues, interoperability, complexity of the technology, governance challenges, business model alignment issues, regulatory uncertainty, and lack of ecosystem readiness among others, as some of the key challenges confronting organisations in their quest to adopt blockchain. Lacity (2018) reiterated similar challenges of blockchain adoption namely lack of standards, regulatory uncertainty, the problem of shared governance, and lack of viable ecosystem. These barriers accordingly constrain the mainstream adoption of blockchain, and thus, further research is required to understand and proffer solutions. Furthermore, Upadhyay (2020) ascertained that, lack of clarity, governance and legal issues, privacy and security concerns, among others, represent significant barriers to blockchain adoption. Lack of clarity stems from the fact that some stakeholders are unclear about the way BT works; the perceived immaturity of BT; lack of skilled human resources; limited knowledge and awareness; uncertainty about integration with existing systems; management of keys and protocols with respect to loss or theft; distribution of copyrighted works, and so on. Privacy and security entails issues like forking of the blockchain, ‘miner’ controls more than 51 percent of the computing power and the immutable nature of the transactions on the blockchain. Immutability is great for permanent record keeping, but this may infringe upon certain privacy laws like the “right to be forgotten” (Rosen 2011) law in Europe.

In response to the identified challenges militating against blockchain adoption, some studies have been conducted and a number of frameworks proposed. The study, “Addressing key challenges to making enterprise blockchain applications a reality” by Lacity (2018), concludes that enterprises need to work together to create standards, and regulators need to clarify compliance requirements. Toufaily et al. (2021) provides a conceptual framework that identifies challenges of blockchain adoption and provides ecosystem expected value. Balasubramanian et al. (2021) also proposes an integrated readiness assessment framework for blockchain adoption that emphasises stakeholders and their strategic relationships. The framework is centered on four readiness dimensions namely motivational readiness, engagement readiness, technological readiness and structural readiness, and offers a comprehensive approach for researchers and policymakers to appraise blockchain adoption readiness of any sector in any country.

Theoretical Foundation

The dominant theoretical foundation underpinning this study is Technology-Organisation-Environment (TOE) framework (Tornatzky and Fleischer 1990). Diffusion of Innovation (DOI) theory (Rogers 1981), also played a pivotal role as guiding theory for the study. Additionally, the study draws from institutional theory since blockchain is a network technology and influenced by network effects. Oliveira et al. (2014) define technology adoption as “The first use of a new product or acceptance of a new technology on a voluntarily basis”. Adoption models generally explain what motivates a business or an organisation to take that voluntary move, to accept and use a technology. The main components of the integrated TOE-DOI framework are technological factors, organisational factors, environmental factors and individual characteristics. The technological factors embody the availability of required technologies both internally and externally for the operation of the organisation. These comprise existing practices and internal apparatuses utilised by the firm, as well as the set of external technologies accessible to the firm (Hage 1980; Starbuck 1976).

From an organizational perspective, the decision to adopt BT must align with the strategic objectives of the business in order to spell out expected results and guide organisational efforts at achieving these objectives (Hiran and Henten 2020). Environmental factors include pressure from global competitors, government regulations, and comprehensive product support, which must be factored in the firm’s decision to adopt a technology. Competitive pressure is the degree of opposition that a company feels from the competition within an industry (Hiran and Henten 2020). These factors may differ based on the economic, social, and political environments in which organizations operate.

Institutional theory argues that institutional environments are critical in shaping organizational structure and actions, including the decision to adopt a technology or not (Scott 2013). According to the theory, organizational decisions are not influenced purely by cogent goals of efficiency, but there are social and cultural dimensions at play, as well as concerns of legitimacy. Institutions are transported by cultures, structures, and routines and operate at multiple levels. According to DiMaggio and Powell (1983), Institutional Theory contends that firms become more analogous due to isomorphic pressures and pressures for legitimacy. The implication of this is that firms sharing the same domain tend to become

homologous over time, as competitive and customer pressures stimulate them to follow industry leaders (Oliveira and Martins 2011). Another theoretical concept underpinning this study is Blockchain-as-a-Service (BaaS), the combination of cloud computing and blockchain. BaaS enables users to leverage cloud-based solutions to create, host and manage their own blockchain apps, smart contracts and functions on the blockchain (Zheng et al. 2019). The BaaS providers manage all the required tasks and activities to keep the infrastructure agile, operational and easily accessible. Given that blockchain is a complex technology and requires the highly skilled to operate, BaaS simplifies deployment by abstracting all the low-level technicalities and details. This simplification is aiding blockchain adoption across businesses in the blockchain ecosystem.

Research Methodology

We employ systematic literature review (SLR) to identify the barriers of blockchain adoption. An SLR, according to Dikert et al. (2016), allows a researcher to establish, evaluate, and understand existing research, and to draw reasonable conclusions based on the outcome of such review. A key objective of systematic review (Coren and Fisher 2006; Kitchenham and Charters 2007) is to deliver evidence in a clear manner pointed at improving the consistency and validity of the research. Therefore, we follow the 3-stage protocol in Briner and Denyer (2012) and Kitchenham and Charters (2007) in order to generate a clear and scientifically driven reproducible literature review of factors inhibiting blockchain adoption. The 3-stage process consists of a) planning the review process, b) conducting the review process, and c) reporting and disseminating the finding.

Data collection for the review was accomplished by searching relevant online databases. Given that Scopus is the largest abstract and citation database of peer-reviewed literature, we elected to search its database for appropriate papers for the review. Peer-reviewed articles have the particular quality of rigour and thoroughness required in academic work. Guided by the objectives of the study, we first performed a pilot search based on which we formulated the final search terms. By using the “Advanced Search” interface of Scopus, two different sections of the database were searched using the search phrase. As shown in Table 1, the phrase, “blockchain AND adoption” was searched in the title (TITLE) section, and the query limited to only English articles of source type journal or conference proceeding. This first search retrieved 155 articles.

Database	Search Interface	Search String	No. of Articles Retrieved
Scopus	Advanced	TITLE (blockchain AND adoption) AND (LIMIT-TO (DOCTYPE, "ar") OR LIMIT-TO (DOCTYPE, "cp")) AND (LIMIT-TO (SRCTYPE, "j") OR LIMIT-TO (SRCTYPE, "p"))	155
		ABS (blockchain AND adoption) AND (LIMIT-TO (DOCTYPE, "ar") OR LIMIT-TO (DOCTYPE, "cp")) AND (LIMIT-TO (SRCTYPE, "j") OR LIMIT-TO (SRCTYPE, "p"))	889
Total			1044
Table 1. Search Phrase and Number of Articles Retrieved			

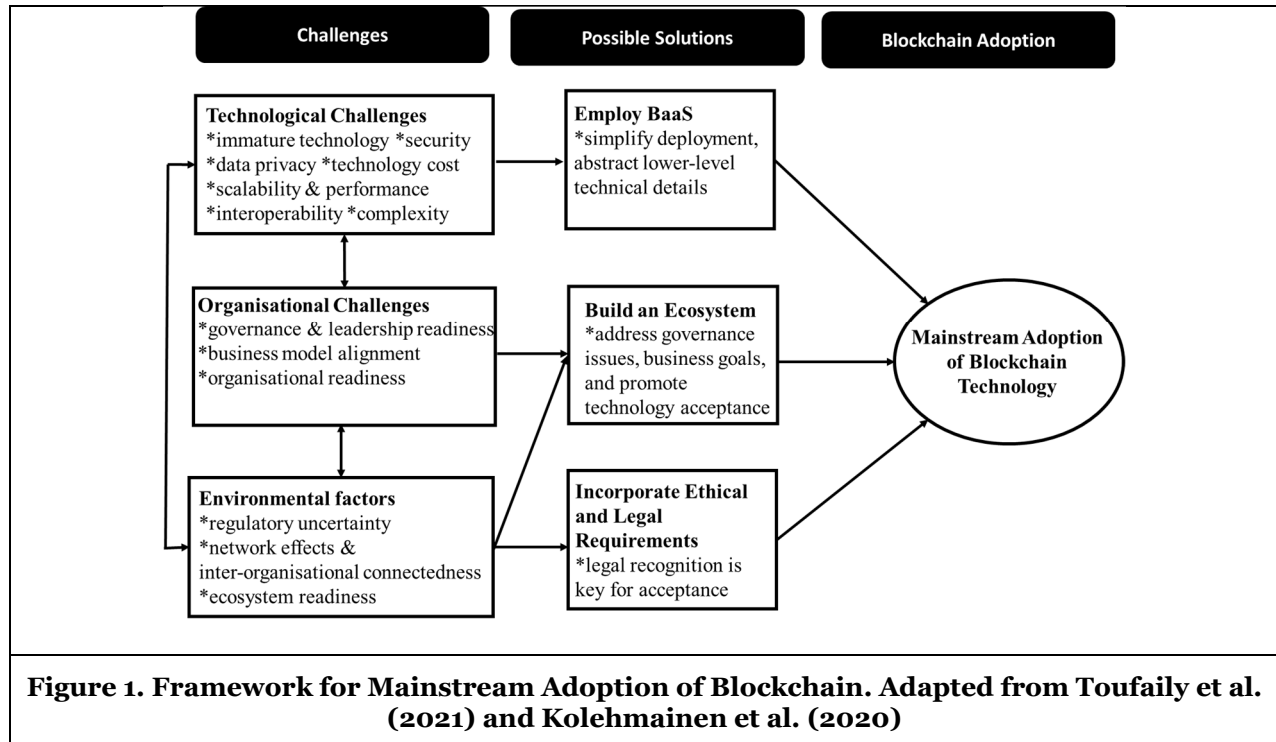
The second search utilised the same phrase “blockchain AND adoption”, but in the abstract (ABS) section with application of the same filter as before, i.e., only English articles of source type journal or proceeding. This search resulted in the retrieval of 889 articles. In total, 1044 articles were retrieved from the database search. The articles retrieved were subjected to filtering using inclusion/exclusion criteria. As first step of the process, duplicates were removed followed by articles in press (AIP) and then articles of type review. Next, we screened the titles of the remaining articles for relevancy. At this point, 154 articles were retained. After further scrutiny, 71 articles remained, whose abstracts were read to determine the final selection of 65 articles for the study.

To achieve a strong, effective and quality evaluation of the research study, the quality matrix according to Pittaway et al. (2004) was followed. By performing such evaluation, and also guided by the theoretical

foundation of the study, the articles were categorized as challenges and possible solutions. The challenges were sub-categorised into technological, organisational and environmental, while the possible solutions were sub-classified under employing BaaS, building an ecosystem and incorporating ethical and legal requirements.

Proposed Framework

Based on the theoretical concepts considered and literature reviewed, we propose the framework in Figure 1. The framework first identifies the key challenges confronting blockchain adoption, then recommends possible solutions which are expected to address the identified barriers and lead to mainstream adoption of blockchain.



Components of the Framework

Challenges

This component identifies the major challenges retarding the general adoption of BT. These include technological, organisational and environmental challenges. Technology immaturity of blockchain highlights the point that blockchain is still at the infantile stage in terms adoption (Toufaily et al. 2021). There are usually four stages in the lifecycle of a technological innovation namely pioneering, growth, maturity and decline. At the pioneering state, organisations are generally cautious about adoption because of high risk, lack of clarity on return on investment, no standards yet and regulatory risks. The other technological challenges include security, data privacy, technology cost, scalability & performance, interoperability, and complexity of BT.

Scalability is peculiar with public blockchains which are permissionless, with all participating nodes having the same authority. However, future solutions are expected to overcome this by connecting private blockchain as second layer on public blockchain (Toufaily et al. 2021). Technology cost, according to Mohammed et al. (2020), can be categorised into two: direct cost, which is the capital expenditure relating to the implementation of blockchain technology, and indirect cost, which is the operational expenditure encompassing the cost of maintaining, upgrading and using the technology. Experts point out that the

interest of every organisation is the return on investment (ROI) and wonder if blockchain can answer that question (Mohammed et al. 2020).

Another factor that can inhibit the adoption of blockchain technology is the lack of awareness and knowledge of the technology (Osei et al., 2021). In their study, most managers interviewed, admitted to not having previous knowledge about the application of blockchain technology. It is obvious such information deficiency will have a constraining impact on the adoption of BT. Another fear is that the integration of blockchain is likely disrupt existing business process. There is uncertainty surrounding the magnitude of this disruption and its impact on business operation. Hence there is laxity with which blockchain adoption is approached by organisations. Also, as Osei et al. (2021) discovered, the reluctance of supply chain partners to disclose strategic information is a bottleneck for the adoption of blockchain technology.

The environmental challenges inhibiting the adoption of blockchain include regulatory uncertainty, network effects and inter-organisational connectedness, as well as lack of ecosystem readiness. The lack of requisite legal frameworks is a major challenge for blockchain adoption around the world although some countries are beginning to deploy sandboxes to bring more regulatory clarity. The bank of Ghana (BoG) recently launched a regulatory and innovation sandbox pilot in collaboration with EMTECH Service LLC, aimed at creating an enabling and inclusive regulatory environment to promote FinTech and support innovation (Bank of Ghana 2021). According to Toufaily et al. (2021), laws and regulations can impact how fast a technology grows. Though regulator attitudes towards BT are largely positive, it is necessary to have agreement on international regulatory principles and cooperation among regulators, due to the cross-border nature of the technology.

Employ Blockchain-as-a-Service (BaaS)

Our proposed framework suggests possible solutions targeted at addressing the key challenges confronting organisations in their blockchain adoption journeys. The first solution is Blockchain-as-a-Service (BaaS). BaaS characteristically entails providing modular infrastructure and tools such as identity management services and middleware, to enable the creation of applications and the integration of legacy systems (Singh and Michels 2018). It is the merger of cloud computing and blockchain, enabling users to leverage cloud-based solutions to build, host and manage their own blockchain apps, smart contracts and functions, on the blockchain (Zheng et al. 2019). Clouds facilitate the outsourcing of skills and expertise with respect to technology deployment and management. Blockchain as an emerging technology implies that experts in that domain are scarce and on high demand. Therefore, the application of BaaS enables technology access, offering abstractions over technical details that only the experts can deal with. BaaS aims at enabling a faster development environment to support businesses in their desire to explore the prospects of BT. Thus, BaaS becomes a sure tool to spearhead the mainstream adoption of blockchain.

Build an Ecosystem

In order to promote the mainstream adoption of blockchain, organisations need to develop an ecosystem thinking. "A blockchain ecosystem basically refers to a network of participants in a blockchain network with shared business objectives, relationships, and processes" (101 Blockchains n.d.). There must be awareness, education and understanding about the advantages and applicability of blockchain among the ecosystem stakeholders (Toufaily et al. 2021). In order to derive business value, organisations should not view blockchain as competitive advantage; instead, the entire ecosystem including customers, partners, authorities and competitors, must be encouraged onto the blockchain platform, to realise the benefits (Lacity et al. 2019). This is the ecosystem thinking that organisations need to develop. Knowledge, regarding business models, the technical aspects, and governance of BT, is key to understanding and implementing the technology. A better comprehension of the blockchain will enable ecosystem participants to work together to create standards, facilitate regulation, safeguard citizens' rights and accelerate the adoption.

Incorporate Ethical and Legal Requirements

Regulatory uncertainty is a key challenge hampering mainstream adoption of blockchain (Toufaily et al. 2021). To promote blockchain adoption, regulatory and legal frameworks must be created alongside the development of new blockchain applications, and these regulations must be enforceable by the blockchain applications (Balasubramanian et al. 2021). This encompasses government policies, directives, regulations,

laws, and judicial interpretations. Contingent on the inclination for innovation, policies can either be restrictive or permissive. Several blockchains are connected with smart contracts which represent the legal validity of these contracts, contrary to traditional ones, and this might be an issue for businesses, according to Giancaspro (2017).

Conclusion and Future Research

BT undoubtedly holds great promises to bring about socio-economic transformation of the world (Vigna and Casey 2016). Notwithstanding, real challenges exist that must be overcome in order to reap the benefits of blockchain. Both academia and industry have responded to some of these challenges through frameworks (Toufaily et al. 2021) and case studies (Lacity et al. 2019; Lacity 2018). The proposed framework in this study adds to efforts by both industry and academia, targeted at addressing key challenges of blockchain adoption. The aim is to facilitate mainstream uptake of BT by industry sectors for which great prospects have been sufficiently advanced in literature and by practitioners. This is believed to unleash the full potential BT for socio-economic transformation. In this regard, future study is encouraged in this area. For example, the framework proposed here can be built using Design Science Research (DSR) methodology and validated through case study.

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